

National Park Service Coastal Visitor Impact Monitoring Phase 2 Report

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Executive Summary

A comprehensive investigation on the applicability, scope and design of a visitor impact monitoring program was conducted at nine coastal areas (seven park units) managed by the National Park Service. This effort in visitor impact monitoring is under the auspices of the Coastal and Barrier Islands Monitoring Network and part of a comprehensive Vital Signs program of monitoring the health of coastal natural resources.

Based on site visits and manager interviews, visitor impacts were found to be a significant threat and management concern at the majority of network parks. Major network-wide impact commonalities include trampling impacts to vegetation and soils, wildlife impacts, impacts related to off-road vehicle use, and trash. Park specific impact problems and monitoring needs were identified through dialogue with staff in each park. Visitor impacts in four park units were found to be less significant and do not warrant further investigation at this time.

Vital signs of visitor impact were selected using both a conceptual model approach to highlight ecological significance and by ranking proposed vital signs based on thirteen important criteria. It is recommended that procedures for a total of ten Vital Sign indicators be developed for application at five of the network areas (four park units) over the next year.

I- Project Background

A research project, “National Park Service Coastal Visitor Impact Monitoring” was initiated in September 2002 as a three-phase study to test candidate variables for future visitor impact monitoring programs at nine park units (seven areas) managed by the National Park Service (NPS). These areas are as follows:

Assateague Island National Seashore, Maryland
Thomas Stone National Park, Maryland
Fire Island National Seashore, New York
Gateway National Recreation Area, New York
Sagamore Hill National Historic Site, New York
George Washington Birthplace National Monument, Virginia
Colonial National Historic Park, Virginia

This “Phase 2 Project Report” summarizes the findings from the first two phases of the project and includes 1) identification of network wide monitoring questions and major impacts; 2) a summary of the scoping results (manager interviews and site visits); 3) compilation of photographic documentation of visitor impacts and management issues; 4) conceptual models of visitor impacts in coastal parks and 5) a prioritized list of candidate impact monitoring variables; 6) a synopsis of NPS Vital Signs sampling techniques and their relevance to visitor impact monitoring and 7) preliminary conclusions on specific monitoring recommendations and future research directions. This report also contains (in appendices) detailed reporting of field activities conducted during the summer 2003. Additional findings to date such as a scientific literature review of coastal visitor impacts and additional full reports from extensive site visits and manager interviews can be found in the Phase 1 Final Report (Monz et al., 2003)

II- Coastal Network-Wide Monitoring Questions to be Addressed by Visitor Impact Monitoring

Considerable research has been conducted over the last 35 years on the consequences of recreational activities on natural resource conditions (Leung and Marion, 2000). This project continues to build on this knowledge in an effort to address the following monitoring questions:

- 1) Which of the NPS areas as listed above are in need of visitor monitoring and visitor impact monitoring programs?
- 2) What are the management areas of critical concern where current or potential visitor activities threaten resource quality and compromise resource protection objectives?
- 3) In areas of critical concern, how is the type, amount and distribution of visitor use changing over time?
- 4) In areas of critical concern, what is the type and extent of visitor impacts to soil, vegetation and wildlife resources and how are these impacts changing over time?

This project is part of the NPS Vital Sign Program that was created for monitoring conditions of important natural resource variables indicative of ecosystem health and resource integrity. Visitors to coastal parks are engaged in a wide array of recreation activities, most of which generate some level of impact. While visitor activity impacts may occur in many areas, impacts occurring within sensitive, natural/pristine or protected zones are of most concern because of the ecological and social value of these areas. Monitoring visitor impacts in these areas is consistent to the objectives of Vital Sign Program and would provide most valuable input to the Program as the impacts may constitute a significant threat to ecological health. This approach parallels the efforts at Cape Cod National Seashore (Marion and Cahill, 2003) and is supported by the findings of the Visitor Use Management Working Group of the Coastal Monitoring Network (Marion, et al., 2001)

III- Summary of Scoping Results and Major Visitor Impacts

Visitors are engaged in a wide variety of activities in the primary ecosystems of coastal areas (Table 1) and in general, managers categorically expressed concern regarding the consequences of these activities to natural resource protection objectives. Given the wide range of managerial objectives and visitor preferences and use levels, the degree of concern and the potential for significant impact to natural resources is highly area dependent. For example, Gateway National Recreation Area, located in the New York City metropolitan area, sees over 8 million visits per year, with many visitors engaged in traditional beach activities such as swimming, sunbathing and sport fishing. In many cases, the popular sites for many of these activities are in proximity to areas managed for high resource protection. Conversely, at Sagamore Hill National Historic Site the majority of visits occur in the museum facilities, with very little current activity on the trails and the small barrier island area. Given these differences, some elements of a comprehensive program of visitor impact monitoring may be area specific, but for the purposes of this project and report, the commonalities of visitor impacts across network parks are emphasized. Site-specific monitoring suggestions beyond the scope of the network-wide monitoring program, are highlighted in the Phase 1 report (Monz et al., 2003) and in the conclusions section of this report.

Table 1. Recreation activities by ecosystem type in coastal areas.

Recreation Activity	Ecosystem Type ¹				
	ES	SM	FW	UP	BD
Bicycling					X
Canoeing/Kayaking	X		X		X
Dog Walking				X	X
Dune Activities					X
Fishing	X		X		X
Harvesting Shellfish and Crabs	X	X			X
Horseback Riding	X	X		X	X
Hunting	X	X	X	X	X
Jogging/Running				X	X
Kite Flying				X	X
Natural Resource Collection	X	X	X	X	X
Nature Observation/Env. Ed.	X	X	X	X	X
Off Road Driving				X	X
Personal Watercraft	X				X
Picnicking	X		X	X	X
Power Boating	X				X
Sunbathing					X
Surfing/Wind Surfing					X
Swimming					X
Walking/Hiking	X	X	X	X	X

¹ Ecosystem types:

ES = Estuaries & near shore environments

SM = Salt Marshes

FW = Freshwater wetlands, ponds, & Streams,

UP = Uplands, forests, grasslands, & thickets

BD = Beaches, dunes, spits, & shoreline systems.

Common visitor activities occurring in network areas with potential resource impact consequences (Table 2) fall in two general categories: 1) those applicable to the development of monitoring indicators in the context of this study (*Study Impact Concerns*) and 2) those beyond the scope of this study but raised by managers (*Additional Impact Concerns*). In general, impact concerns deemed beyond the scope of this study are primarily in front country areas or in areas of concentrated visitor use where resource monitoring would be of little management utility. Concerns of both types are mentioned and discussed in this section in order to provide a full summary of the scoping results. In some cases where managers have expressed an exceptional need, an additional impact concern not covered by network-wide approaches will be addressed by a site specific study. These components of the project will be addressed in the conclusions section.

Table 2. Common visitor impacts to selected parks.

Impacts	SIC/ AIC ¹	PARKS ²				
		ASIS	COLO	FIIS	GEWA	GATE
Adjacent Residential Impacts	AIC		X	X	X	
Bicycling	SIC		X			X
Camping Impacts	SIC	X	X	X	X	X
Canoeing/Kayaking Impacts	SIC	X	X	X		
Cultural Resource Damage	AIC				X	
Damage to Dune Habitat	SIC	X		X		X
Dumping of Pets and Wild Animals	AIC		X	X		X
Fires	AIC					X
Human/Fecal Runoff	AIC					X
Hunting Impacts	SIC	X	X	X		
Illegal Harvesting of Natural Resources...	AIC	X	X		X	X
Illegal Parking	AIC				X	
Impacts from Horses	AIC/SIC	X				X
Littering/Trash	AIC	X	X	X	X	X
Management/Maintenance Activities	AIC		X			
Off-Road Vehicle Use	AIC/SIC	X		X		X
Pets	AIC/SIC			X		X
PWC/Motorboat	AIC	X		X		X
Runoff from Roads/Asphalt	AIC	X		X		
Shorebird Disturbance	SIC	X		X		X
Soil Disturbance	SIC	X	X	X	X	X
Trampling Vegetation	SIC	X	X	X	X	X
Vandalism	AIC		X			X
Water Contamination	AIC		X	X		X
Wildlife Disturbance	SIC	X		X		X

¹ SIC = Study Impact Concerns; AIC = Additional Impact Concerns,

² NPS area abbreviations: ASIS = Assateague Island National Seashore,
COLO = Colonial National Historic Park, FIIS = Fire Island National Seashore,
GEWA = George Washington's Birthplace National Monument,
GATE = Gateway National Recreation Area

A. Network-wide Impact Commonalities

- 1) Trampling impacts to vegetation and soils. All areas reported and we observed both current and potential impacts to dune and upland vegetation communities as a consequence of day and overnight use. Trampling is primarily caused by foot traffic, in areas where visitors are dispersing and traveling off established trails and boardwalks. In Colonial NHP, mountain biking use is also the source of vegetation and soil disturbance and throughout the parks, illegal ORV use can also result in these impacts. In most cases, managers report that little if any information exists on the location and extent of these impacts and whether

impacts are changing over time. In some cases these impacts are localized, in point areas that attract visitors (i.e., campsites, coastal access points for fishing) and off hardened or resistant substrates (i.e., boardwalks and sand, respectively). In other cases these concerns are more widespread, such as the impacts of beach visitors to coastal sea beach amaranth, or the proliferation of trails from beach areas on to the dune ecosystems.

- 2) Wildlife Impacts. Although managers raised some area specific wildlife impact issues, two overall concerns were raised by managers at several areas:
 - a. The impact of visitors on piping plover (*Charandrius melodus*) and other beach nesting birds. Piping plovers and other seabird species occupy sand beaches and tidal flats and their numbers have been declining in recent years due to the extensive beach disturbance. The vast majority of visitors to these areas are primarily interested in beach recreation and consequently there exists an ever present possibility of impacts to these species. Although significant management efforts are generally in place to limit visitor disturbance and preserve habitat during nesting season, it is not clear in all cases as to the level of visitor compliance with exclosures or the degree to which visitors in adjacent areas are causing a wildlife disturbance response.
 - b. Illegal harvesting and interaction with wildlife. Assateague and Gateway have concerns about the harvesting of fish, crabs, clams, and horseshoe crabs. Gateway experiences the illegal poaching of these animals and managers do not know the extent of impact caused or exactly how to prevent such activities. Managers at Assateague are concerned with the feeding and contact that visitors have with the wild horses.
- 3) Off Road Vehicle (ORV) Use. Managers at Assateague, Gateway and Fire Island have raised concerns about the impacts of ORVs to coastal dune flora and fauna. At each of these areas, ORVs are limited to designated zones, specific trails and/or travel corridors. In most cases total numbers of ORVs are limited by permit systems. Manager's observations would suggest that the nature and extent of ORV use has changed substantially at these areas over the last 10-20 years with increases in numbers of visitors and shifts in visitor activity preferences. At Assateague, for example, previous ORV use was limited to a large extent to visitors engaged in sport fishing activities. As such, visitors would drive to an area above the tide line and park. Recently with the popularity of sport utility vehicles, more visitors are coming just to drive the beach, picnic, have campfires, swim or to day hike into the nearby dune and forest communities. Given the scope and extent of this project, we will not be developing *network-wide* monitoring indicators to address specific issues within the designated ORV zones, trails or corridors, though a specific measurement of ORV use distribution will be developed for Assateague based on the park's specific information need. Monitoring protocols will address any impacts in natural areas adjacent to ORV zone where visitors may be traveling on foot or (illegally) by vehicle.

- 4) Trash. The presence of trash on the beaches, marshes and other areas is a ubiquitous and constant management concern. In addition to the obvious impact to the visitor experience, concerns have been raised as to the effects of trash on wildlife. Many areas have active programs in beach cleaning, which is effective in some cases. Trash represents a difficult monitoring issue since much of the trash is floating debris from the nearby metropolitan areas and therefore does not originate from park visitors.

IV- Summary of findings from Additional Park Visits

Gateway National Recreation Area (GATE), Fire Island National Seashore (FIIS), Assateague Island National Seashore (ASIS) and Colonial National Historic Park (COLO) received additional site visits during the second phase of the project in order to further assess the extent and location of impacts at these complex areas and to conduct some preliminary feasibility studies on the methodology of shorebird disturbance and visitor-wildlife interaction. The additional visit to ASIS and COLO reconfirmed the study impact concerns and, through discussion with park managers, identified specific high-priority sites to be included in field testing of indicators in the next phase. With respect to GATE and FIIS, specific park areas in need of monitoring and possible indicators were identified (Table 3). Full site visit reports are included in appendix 1.

Table 3. Summary of results from site visits to FIIS and GATE

<i>NPS UNIT</i>	<i>Primary impact concerns raised by managers</i>	<i>Study Impact Concerns to be examined</i>	<i>Type of AIC present</i>	<i>Possible indicators/ monitoring strategies to be examined</i>
GATE-Breezy Point	Shorebird disturbance/ residential use/ORV	Shorebird Disturbance, vegetation disturbance	Shorebird disturbance (common tern)	Attraction behavior, soil exposure, social trail formation, visitor use
GATE-Bergen Beach	Social trails, vegetation trampling, dune damage, horse use impacts	Vegetation disturbance	Horse use impacts	Soil Exposure, social trail formation
GATE-Fort Tilden/Riis Park	Shorebird disturbance, trampling of vegetation	Shorebird disturbance, vegetation disturbance		Attraction behavior, disturbance type and time
GATE-Sandy Hook	Vegetation trampling, trash, shorebird disturbance, illegal harvesting,	Social trail and site formation, shorebird disturbance		Soil Exposure, social trail and site formation, Attraction behavior, disturbance type and time
GATE-Staten Island/Great Kills	Trash, water pollution, social trails	N/A	N/A	N/A
FIIS-Beach Areas	Shorebird disturbance	Shorebird disturbance		Attraction behavior, disturbance type and time
FIIS-Old Inlet	Vegetation disturbance	Vegetation disturbance		Soil exposure, social trail and site formation
FIIS-Otis Pike Wilderness Area	Vegetation disturbance, visitor created sites and trails	Vegetation and soil disturbance		Soil Exposure, social trail and site formation
FIIS-Sexton Island	Shorebird disturbance	Shorebird disturbance		Attraction behavior, disturbance type and time
FIIS-Hospital Island	Soil and vegetation impacts	Social trail and site formation		Soil Exposure, social trail and site formation

V- Suitability of NPS Units for Visitor Impact Monitoring Program

Overall suitability of NPS areas for a program of visitor impact monitoring was evaluated based on four criteria (Table 4). This is an important component of the initial phases of the project as areas vary considerably in overall visitor management objectives and in the degree of natural resource protection possible. As mentioned previously, visitor impact monitoring is more desirable in areas or zones where resource protection is a high priority and dispersed recreation is occurring. As such, three NPS areas did not meet these criteria (GATE- Staten Island Unit, SAHI and THST) and one area (GEWA) only partially met these criteria. Monitoring program development is suggested at all areas with a high importance of monitoring rating (Table 4).

Table 4. Suitability ranking of NPS areas for visitor impact monitoring

Park Selection Criteria	Suitability Rating by Park ¹								
	ASIS	COLO	FIIS	GATE- JB	GATE- SH	GATE- SI	GEWA	SAHI	THST
Significant Resource Protection Areas (RPA)	+	+	+	+	+	-	+	0	0
Visitation common in or near RPA	+	+	+	+	+	N/A	0	-	-
Active management of visitor activities	+	+	+	+	+	0	+	+	-
Facility solutions not practical or desirable in RPA	+	+	+	+	+	-	0	-	-
Overall importance of monitoring	High	High	High	High	High	Low	Med	Low	Low

VI- Conceptual Model Approach to Indicator Selection

The selection of accurate and appropriate vital signs of resource conditions is essential to the development of any program of long-term monitoring. For this project, a two-step process informed the selection of vital sign indicators. First, conceptual models of the interactions of agents of change, stressors and ecosystem responses were developed for visitor impacts in coastal ecosystems and for the soil, vegetation and wildlife responses within those ecosystems. This conceptual model approach is helpful to illustrate the mechanisms of impact and the ecosystem-level consequences of those impacts and is similar to other approaches of ecological indicator selection adopted by the NPS. (Crabtree and Bayfield, 1998; Dale and Beleyer, 2001; Olsen et al., 1992). Second, a matrix of desirable vital sign attributes was developed to aid the decision making process of identifying specific feasible indicators. This section describes the conceptual model approach (Figs. 1-4) while the attribute matrix is described in the final section.

A. Overall Ecosystem Model

For the overall ecosystem model (Fig. 1), three agents of change are identified: visitor/recreation use, resource consumption and land use. Marion et al., (2001) identified a range of visitor activities in coastal parks and these include jogging, hiking, volleyball, sunbathing, off-road vehicle use, camping, dog walking, etc. Each of these forms of activities can result in unique impacts. Resource consumption is defined as any activity leading to a direct harvest of flora and fauna including fin fishing, shell fishing, hunting, and collecting. The land use component includes direct effects as a consequence of visitor activities such as facility development, and access development. These three agents result in four major stressors including over-harvesting, invasive species introductions, biotic disturbance, and altered physical environment. The stressors lead to changes within the ecosystem such as, changes in the ecosystem structure or changes in the physical or chemical environment.

B. Vegetation Disturbance

For the vegetation model (Fig. 2), five specific agents are identified, visitor density (the amount of visitors concentrated in one area), visitor distribution (spatial/temporal), visitor activity type (behavior and type of recreation activity), and visitor transportation (by what means they are traveling in the area of concern), and resource consumption (harvest of plant or plant parts).

Trampling, stem breakage, and collecting of plants or plant parts cause damage to plant structures and may result in displacement of plant species or changes in plant populations. The extent of damage depends on the degree of each agent of change. Through these disturbances, changes in plant populations occur, including direct mortality, reduced vigor, reduced reproduction, and species cover loss. These stressors result in four major ecosystem responses: direct introduction of plant species, species composition change, changes in competitive interactions, and changes in primary production.

C. Soil Disturbance

Four agents of change can lead to soil disturbance: visitor density, visitor distribution, visitor activity type, and visitor transportation (Figure 3). These agents lead to soil disturbance, which occurs through trampling, scuffing, displacement of soil, vehicle tracks, etc. The ecosystem responds to these stressors by soil compaction, soil exposure, and reduction in air, water, and root permeability. The exposure of soil results in erosion, loss of organic matter, loss of soil nutrients, and changes in the soil texture. Changes in soil biota and nutrient cycling occur when there is a reduction in air, water and root permeability and results in erosion, loss of organic matter, loss of soil nutrients, and changes in the soil texture.

D. Wildlife Disturbance

As in the vegetation model, five agents of change can lead to wildlife disturbance (Fig. 4). The three resulting stressors direct disturbance, habitat modification, and pollution/trash can cause wildlife to alter their behavior or may alter the energy balance of the affected individuals. The ecosystem consequences of these stressors can be direct mortality of individuals in the affected population, altered productivity of the population (increase or decrease) and species displacement from preferred habitat. Ultimately species composition and population numbers are affected as well as competitive interactions within and among species.

Figure 1. Overall model of visitor impacts to coastal ecosystems.

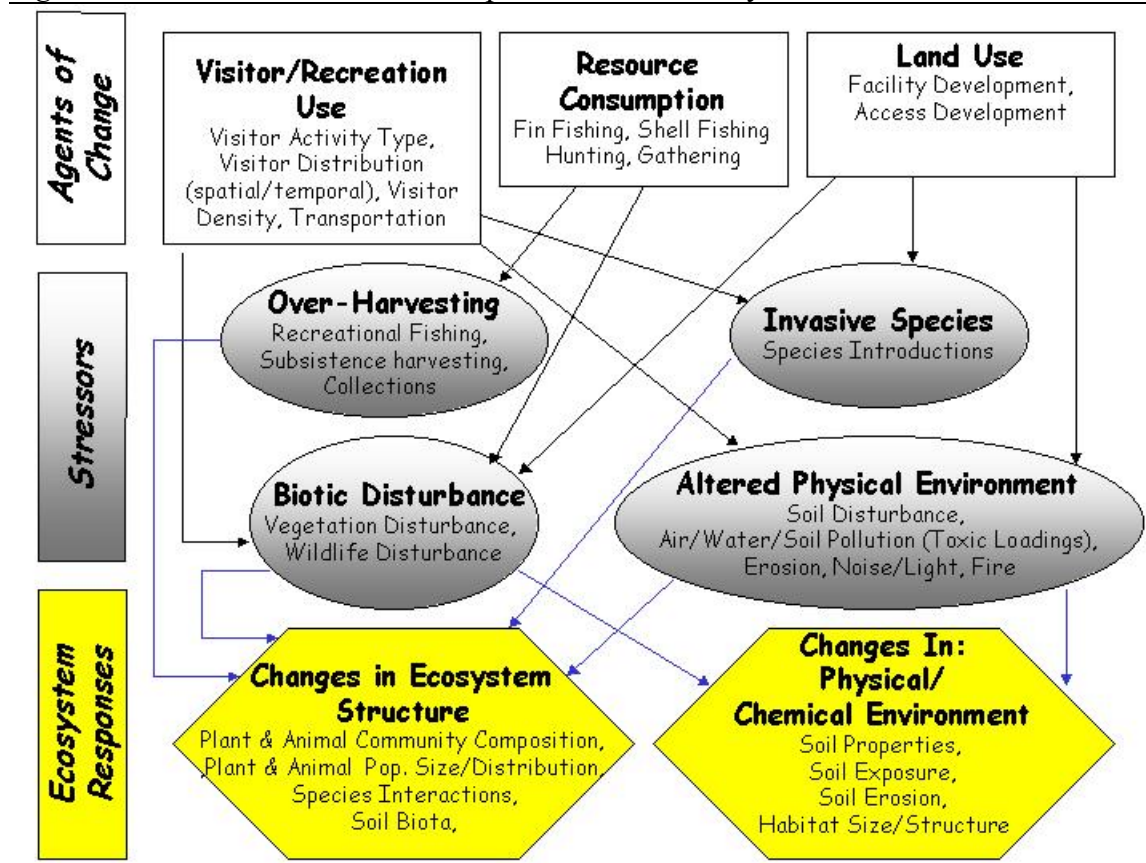


Figure 2. Conceptual ecosystem model of visitor impacts to vegetation.

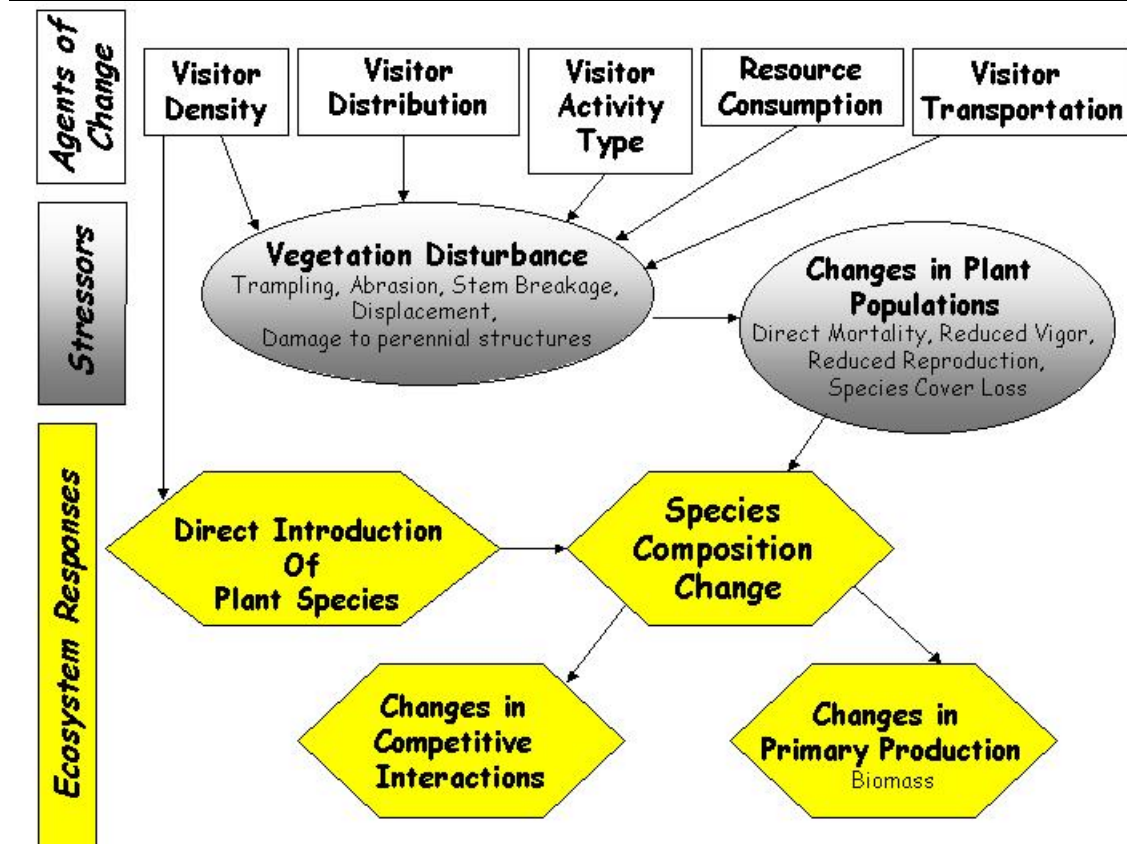


Figure 3. Conceptual ecosystem model of visitor impacts to soils.

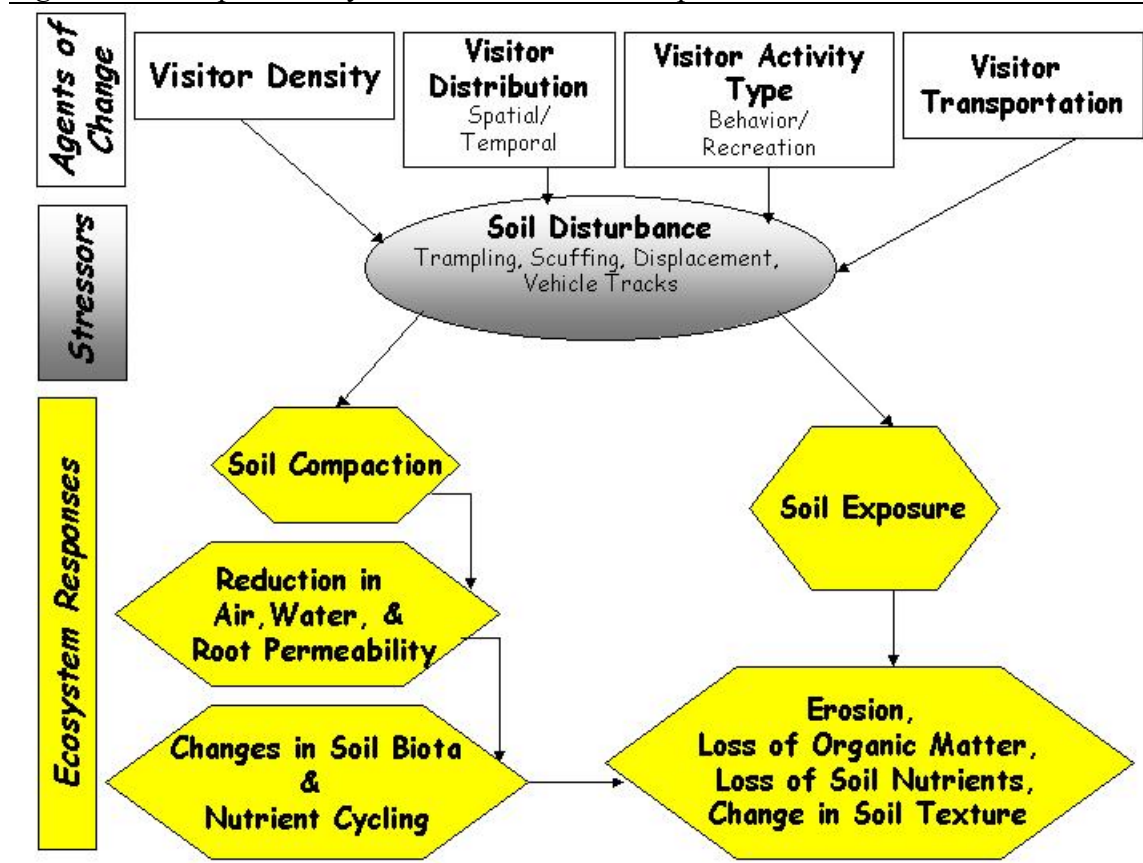
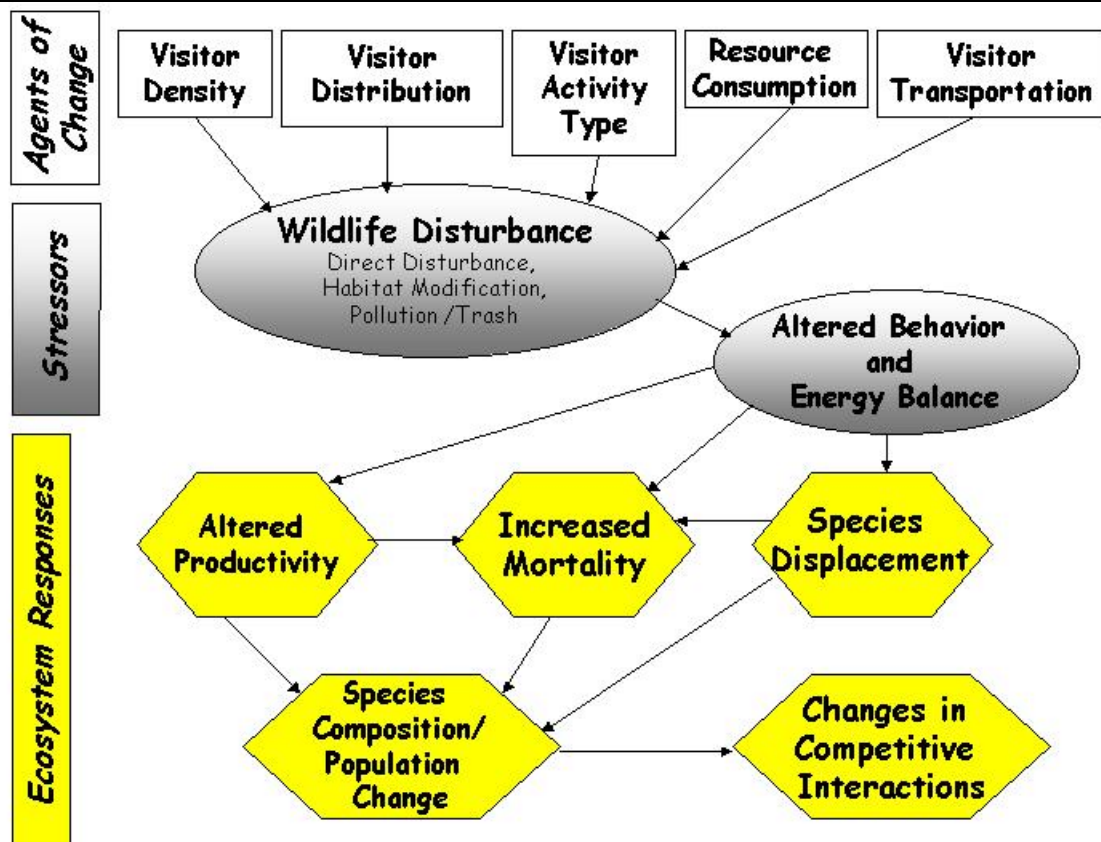


Figure 4. Conceptual ecosystem model of visitor impacts to wildlife.



VII. Candidate Vital Signs

Vital signs, sometimes referred to as ecological indicators, are defined as measurable features of the environment that provide insights into the state of the ecosystem. The National Park Service strives to identify and monitor vital signs of environmental health in parks as a means of sustaining the health of park resources and managing threats to their well being proactively. Monitoring vital signs provides the foundation for this approach by evaluating efficacy of management actions and by warning of impending threats to park ecosystems (Fancy, 2003).

Natural resource impacts associated with visitor use in the form of outdoor recreation, tourism or ecotourism have been identified as one of the five major ecological threats to the NPS units within the Northeast Coastal and Barrier Network (Milstead, 2003). Accordingly, vital sign indicators of visitor impacts need to be developed as an integral part of the overall Network's vital signs monitoring program. The process of indicator development includes indicator identification, indicator ranking and selection, sampling strategy determination, and field testing and verification. The following describes the first two steps of the indicator development process and concludes with a prioritized list of candidate vital sign indicators.

A. Identifying Candidate Vital Signs

Throughout the Phase 1 research of this project a variety of sources were consulted to identify candidate vital signs of visitor impacts for the Network. These sources included scientific literature (Ingle et al., 2003; Leung and Marion 2000), experiences from recent studies within the Network or nearby areas (Manning, Leung and Budruk, 2003; Marion and Kahill 2003), results from the Visitor Use Monitoring Work Group Report (Marion et al., 2001), results from interviews with park staff (Monz et al., 2003; Section III this report), and the conceptual models developed for visitor impacts (Section IV this report). These candidate vital sign indicators represent three major components of visitor impact conceptual models, namely agents of change or pressure, stressors and ecosystem responses (Crabtree and Bayfield, 1998; Dale and Beleyer, 2001; Olsen et al., 1992). A summary of the identified candidate vital signs, monitoring approaches and vital sign measures is provided (Tables 5 , 6 and 7).

Table 5. Candidate vital signs, monitoring approaches and specific measures for the agents of change in the natural zones.

Candidate Vital Sign	Monitoring Approach	Vital Sign Indicator Measure(s)
Visitor Activity Type	Managers Survey Direct Field Observation Entry Point Visitor Survey	Dominant activity type; Composition of different activity types
Visitor Density	Managers Survey Direct Observation Trail Counters	Scale Ratings of use Frequency Observed number of visitors by activity type Number of hikers along selected trail segments
Distribution of Visitor Use	Managers Survey Direct Observation Trail Counters	Location and extent of recreational use

Table 6. Candidate vital signs, monitoring approaches and specific measures for soil and vegetation degradation in natural zones

Candidate Vital Sign	Monitoring Approach	Vital Sign Indicator Measure(s)
Vegetation Loss/ Soil Exposure	Direct On-site Measurement at recreation sites and along trails Air photo image processing	Relative cover loss (%) Changes in soil exposure (%)
Vegetation Compositional Change	Direct On-site Measurement at recreation sites and along trails	Individual Species Cover (%) Presence/Absence of invasive plant species
Social Trail Formation	Direct On-site Assessment and Mapping Air photo image processing	Location, extent and mapping of visitor-created trails
Unofficial Site Formation	Direct On-site Assessment and Mapping Air photo image processing	Location, extent and mapping of visitor-created sites
Shoreline Disturbance	Direct On-site Assessment and Mapping in sensitive areas	Location, extent and mapping of shoreline disturbance sites
Disruption of Submerged Aquatic Vegetation	Direct On-site Assessment	Location and Extent of disturbance

Table 3. Candidate vital signs, monitoring approaches and specific measures for wildlife disturbance in natural zones

Candidate Vital Sign	Approach	Vital Sign Indicator Measure(s)
Disturbance type	Direct Behavior Observation	Type of visitor activities affecting wildlife (i.e., shorebirds)
Disturbance time	Direct Behavior Observation	Length of time of disturbance events
Attraction Behavior	Direct Behavior Observation	Number of occurrences of wildlife feeding Number of occurrences of attraction behavior

B. Criteria for Ranking Vital Signs

Due to time, monetary and other logistical constraints, not all of the above candidate vital signs can be implemented in the Network's vital sign monitoring program. A systematic process of ranking and selecting candidate vital sign indicators is therefore an essential next step.

Selection criteria of ecological and sustainability indicators in general (Consulting and Audit America, 1995; Jackson et al., 2000) and visitor impact indicators specifically (Belnap 1998; GYWVU 1999, Manning, Leung and Budruk, 2003) were reviewed. It resulted in thirteen selection criteria proposed for this project (Table 4). Four are required criteria that must be met by the candidate indicator if it is to be considered for selection. The remaining nine are optional criteria that are used for evaluating the desirability of candidate indicators even though they may have met the required criteria.

Table 7. Evaluation Criteria for Candidate Vital Sign Indicators*.

CRITERIA	DESCRIPTION
Low measurement impacts	The indicator can be measured with no or minimal level of ground disturbance
Reliable/Repeatable	The measurements of indicator by different field staff would show reasonable agreement
Correlation with use	The indicator is directly related to visitor use with good level of correlation
Ecologically relevant	The indicator must have conceptual relevance to concerns about ecological condition, i.e., it must be a component of the appropriate conceptual model. It must reflect an important change of resource condition that would lead to significant ecological or social consequences
Respond to impacts	Change of resource condition can occur promptly after impacts are introduced
Respond to management	Resource conditions can be manipulated by management actions
Easy to measure	Field measurements are relatively straightforward to perform with minimal level of equipment needed
Low natural variability	Indicator has a limited level of spatial and temporal variability
Large sampling window	Field measurements can take place in most of the times in a year
Cost effective	Measurements of indicator are inexpensive. Little additional cost to management. Data gathered benefit management
Easy to train for monitoring	Field staff with no prior knowledge of field procedures can be easily trained to perform such procedures
Baseline data	There are existing data on the indicator, preferably with the use-impact link established
Response over different conditions	Impacts can be seen while still relatively slight

* The first four criteria are required while the remaining nine are desirable criteria. These criteria were adapted from Belnap (1998), Consulting and Audit Canada (1995), GYWVU (1999) and Manning et al. (2003).

C. Ranking Results: Prioritized List of Candidate Vital Signs

All twelve candidate vital signs identified in Section A were evaluated against the thirteen criteria described in preceding section. Table 5 provides a summary of the evaluation process in form of a two-dimensional matrix. The result is presented as a prioritized list of candidate vital signs (Table 6). High priority indicators are those to be recommended for adoption in the Network's vital signs monitoring program, while the low priority indicators will not be recommended. After selecting vital sign indicators specific indicator measures will be evaluated and compared based on their cost effectiveness and performance.

Table 8. Evaluation Matrix of Candidate Vital Sign Indicators for Visitor Impacts.

SELECTION CRITERIA*	CANDIDATE VITAL SIGN INDICATORS											
	<i>Visitor Activity Type</i>	<i>Visitor Density</i>	<i>Dist. of Visitor Use</i>	<i>Vegetation Loss/Soil Exposure</i>	<i>Vegetation Composition Change</i>	<i>Social Trail</i>	<i>Unofficial Sites</i>	<i>Shoreline Disturb.</i>	<i>Submerged Aquatic Veg.</i>	<i>Wildlife Disturb. Type</i>	<i>Wildlife Disturb. Time</i>	<i>Attraction Behavior</i>
Low measurement impacts	+	+	+	+	+	+	+	+	+	+	+	+
Reliable/Repeatable	0	0	0	0	0	0	+	0	0	0	0	0
Correlation with use	+	+	+	+	+	+	+	?	?	+	+	+
Ecologically or socially relevant	+	+	+	+	+	+	+	+	+	+	+	+
Respond to impacts	+	+	+	+	+	+	+	+	?	+	+	+
Respond to management	+	+	+	+	+	+	+	+	+	+	+	+
Easy to measure	+	+	0	+	?	+	+	+	+	0	0	+
Low natural variability	+	+	+	+	+	+	-	0	0	?	?	?
Large sampling window	+	+	+	+	+	+	+	+	+	+	+	+
Cost effective	0	0	0	0	0	0	+	+	+	+	+	+
Easy to train for monitoring	+	+	+	+	+	0	+	0	?	+	0	0
Baseline data	0	0	-	0	-	0	-	-	-	0	0	0
Response over different conditions	+	+	+	+	?	+	+	?	?	?	?	?
Priority	M	M	H	H	M	H	H	L	L	M	M	H

* The first 4 criteria are required while the other 9 are desirable criteria.

+ = Criterion satisfied 0 = criterion partially satisfied (or varies by zone/area) - = criterion not satisfied

? = questionable/undecided

n.a. = not applicable

Table 9. A prioritized list of candidate vital signs.

Priority	Candidate Vital Signs
<i>High</i>	1) Distribution of Visitor Use
(Recommended for Adoption in CBN Vital Signs Monitoring Program)	2) Vegetation Loss/ Soil Exposure
	3) Social Trail Formation
	4) Unofficial Site Formation
	5) Attraction Behavior
	6) Visitor Activity Type
<i>Medium</i>	7) Visitor Density
	8) Vegetation Composition Change
	9) Wildlife Disturbance Type
	10) Wildlife Disturbance Time
<i>Low</i>	11) Shoreline Disturbance
	12) Submerged Aquatic Vegetation
(Not Recommended for Adoption in CBN Vital Signs Monitoring)	

VIII. Sampling Considerations for Visitor Impact Monitoring

With any element of resource monitoring careful consideration should be given to the statistical accuracy and representative nature of the sampling design. Specific and extensive guidelines for the assessment of park biological resources have been suggested in the context of the NPS Inventory and Monitoring program (Fancy 2000; Geissler and McDonald 2003). These guidelines provide a basis for the determination of the sampling design of this study. The nature visitor impact requires additional considerations that in some cases may supercede standard biological sampling protocols, especially when factors such as the efficiency and cost effectiveness are examined.

A. Spatial Scale Considerations

As discussed under section II of this report, sampling will be restricted to areas adjacent to or within zones of high resource protection where some level of dispersed visitation is occurring. Although visitor activity impacts may occur in many park areas, impacts occurring within sensitive, natural or resource protection zones are of most concern because of their ecological and social value. Monitoring is of primary importance in these areas as visitor impacts can pose a substantial threat to ecological integrity.

Visitor impacts often exhibit predictable patterns spatially as recreationists often consistently use the same or adjacent places on the landscape (Hammit and Cole 1998). As such, recreation impacts tend to be highly concentrated in nature with use and impacts restricted to travel routes (trails) and destinations (sites). This phenomenon has been described a node and linkage patterns, with nodes of impact forming at destination areas and linkage impacts forming along routes, between nodes (Manning 1979). Given these patterns and that it is generally possible to locate visitor impacts (i.e., soil and vegetation) and potential impacts (i.e., wildlife interactions), large scale, grid based sampling designs are typically not utilized in visitor impact monitoring. As in many visitor impact studies, this study will rely on the predictable node- linkage pattern combined with information on visitor use and distribution to locate and determine the extent of resource impacts. Preference will given to environmental settings that are most sensitive to the negative effects of visitation especially areas with rare, endangered, or sensitive species.

In addition, some vital signs, for example soil exposure, can potentially be measured effectively across the landscape using remote sensing techniques. In addition to providing an excellent integrated measure with little associated sampling error, such a measure would act as an early warning of new site and trail formation in areas previously undiscovered by ground based assessments. Development and implementation of these remote sensing techniques will be a major effort in the next phase of this study.

B. Permanent Plot Re-measurement

Permanent plot designation and subsequent re-assessment is desirable for NPS vital signs monitoring (Fancy 2000) and lends well to visitor impact monitoring. Typically visitor sites and trails are mapped and assessed in such as way as to allow for the relocation of

assessment points over time as the changes in existing trails and sites form a strong indicator of overall impact trends. This technique will be used extensively throughout the design and testing phase of this project.

C. Sampling Within Visitor Nodes and Linkages

Sampling strategies for the determination of impacts within visitor nodes (sites) and linkages (trails) are well developed and have been extensively reviewed (e.g., Hammitt and Cole 1998; Monz 2000; and others) and applied (e.g., Marion 2002 a & b). For this study, we will follow these well established protocols. Typically for trails, impact *measurements* (trail width, depth, etc.) are performed at regular intervals systematically along individual trail segments while other *estimates* of integrated variables, such as condition class ratings, are performed more continuously as the trail assessment proceeds. This combined approach has the advantage of providing information that is able to characterize entire trails segments and also plot-specific so that areas can be re-measured for future trends.

Visitor sites are often measured using assessment procedures that integrate impact measurements across the entire site. This approach is effective in areas where sites are relatively small (i.e., 5-10 m in diameter) and specific impact variables, such as vegetation cover loss, can be determined adequately for the entire site by visual estimates. In larger areas, and for some measurements (e.g., soil compaction), random or grid-based subsampling schemes are desirable and will be utilized. Also, the next phase of the project will include some methodological development examining the use of image analysis of site photos for vegetation cover estimates.

IX. Park Specific Monitoring

In addition to network-wide indicators, monitoring procedures may be needed to address specific but significant visitor impact concerns within one or several park units within the Network. For instance, monitoring procedures are being developed for Assateague Island to address two major visitor impact issues, namely human-horse interactions and ORV use distribution. While these are specific concerns in ASIS, the sampling and monitoring procedures are being developed with broader applicability to other parks in mind.

A review of literature reveals that a variety of sampling and recording methods have been developed to quantitatively document the extent and distribution of human-wildlife interactions (Martin and Bateson 1993; Lehner 1996). Animals examined include brown bears, black bears, ground squirrels and sanderlings. Based on the experience of the first pilot testing of draft procedures in August 2003 a monitoring method using behavior observation approach is proposed for further testing. Essentially this proposed method involves two field staff and applies behavior sampling of visitor-horse interactions and one-zero (presence/absence) recording procedures (Martin and Bateson 1993). Special field forms along with several electronic tools, such as GPS unit, laser rangefinder, compass, and digital camera, will be employed to document interaction events. The data yielded would provide insights on the spatial and temporal patterns of interactions and

the problem horses involved. Parts of this method are intended to be generic and applicable to investigate visitor interactions with other animal species.

A simple measure of ORV use distribution is also being developed for ASIS. Currently the park has accurate records of the amount of ORV use in a given time as set by the capacity limit. However, there are no data on how these vehicles are distributed in space. Such information is deemed crucial by park staff and will be useful for evaluating visitor impacts along and outside the ORV zone. The existing kilometer markers established in the ORV zone may be utilized for recording location of ORVs. This method is expected to be efficient enough to be applicable by park staff through regular patrol or by park volunteers with minimal amount of training needed.

X. Conclusions and Phase 3 Research Directions

In light of the extensive site visits, manager interviews and a full review of the scientific literature regarding visitor impact monitoring, the following overall conclusions for network areas are provided. These points will be basis for the development of a full proposal in December 2003 for the testing of field protocols during Phase 3 of this project. Upon conclusion of Phase 3 (in 2004), specific field and data gathering protocols will be developed that will allow the integration of these results with the broader objectives of the Coastal and Barrier Island Network.

A. Network Areas in Need of Monitoring

Based on our evaluation criteria (Section V; Table 4), the monitoring of visitor impacts is appropriate at the majority of network areas, with four areas receiving a low or medium priority rating for the application of monitoring approaches. We suggest that monitoring protocols be developed in all areas with a high overall importance of monitoring (Table 4) and other areas not be included at this stage. Should visitor use levels or management priorities change at these areas, it would be possible to adapt monitoring protocols to these areas in the future.

B. Prioritized Vital Signs

Arguably the most important component of this phase of the project has been the clarification of potential vital signs and a clear process to determine the relative importance of each in coastal environments (Table 9). Moreover, linking each vital sign to the ecological impact process (i.e., the conceptual model) further clarifies their role and importance. We suggest that this process is more broadly applicable to a range of environments where visitor impacts are a concern.

Specifically, for the next phase of this project, we recommend that all vital signs with a high and medium priority be examined thoroughly for application at specific sites at each of the appropriate network areas. For vital signs with a low priority, no further application is suggested. In cases where we have highlighted some park-specific

monitoring concerns (Section IX), other vital signs may be assessed as appropriate to address managerial needs.

C. Vital Sign Measures in Need of Further Development

Given the complexities of assessing specific vital signs across the network and the need to develop cost-effective, objective measures, two new methodologies seem particularly promising to augment more traditional site specific assessment procedures. The use of remote sensing (aerial photography) to determine the extent of soil exposure and visitor-created trail formation seems particularly promising. Procedures for conducting these analyses will be investigated and if possible, fully developed in Phase 3. Our preliminary investigations into the availability and utility of image data and the feasibility of the basic approach indicate that this may be an effective method, particularly in these coastal environments. To date, few actual applications of remote sensing for this purpose have been found in the literature, and it will be challenging to develop an accurate and cost-effective method. Nonetheless the return on the use of this monitoring strategy, if effective, will be high and we therefore suggest that this be a major component of our future research on the project. The use of image analysis on a site level will also be investigated as a means of determining soil exposure and vegetation loss more objectively than traditional visual estimates.

D. Phase 3 Proposal for Future Research

A proposal detailing specific sites and vital signs measures to be tested during the 2004 field season will be prepared by December 2004. Our overall goal for this future phase will be to develop specific protocols for network wide application of monitoring strategies and to field test all possible vital signs measures.

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Appendix 1
Visitor Impact Concerns in FIIS and GATE
Second Phase Site Visit Report
July 8, 2003

Project Staff Present: Christopher Monz, Heather Bauman, and Erica Young

This report documents the findings of the second site visit to Fire Island National Seashore and Gateway National Recreation Area. During this visit we met with park managers and spent more time in the field focusing in on the Otis Pike Wilderness and other areas of high resource protection. Piping plover, tern, and other shorebird protection zones were visited. Many of these visitor-restricted zones also protect sea beach amaranth. Each site visited was assessed to determine if monitoring within the scope of this project would be helpful.

Fire Island National Seashore

Park Staff Present: Paula Valentine and Marie Lawrence

Otis Pike Wilderness Area

The Otis Pike Wilderness Area is our focus on Fire Island. Many social trails were found within the wilderness area, mostly occurring at the end of boardwalks and off of the Burma trail, which runs the length of the island. Other social trails might extend into the wilderness area from the ocean side where blowouts have occurred. Blowouts are where the ocean has pushed through the dunes and has created a washed out flat sand area. Many curious visitors might wonder down these into the wilderness.

The ocean side of the Otis Pike Wilderness area is another place visited. Because most visitors to Fire Island go to the beach managers have put up plover enclosures around nest sites. These sites are at times disturbed by dogs and/or visitors. The extent of the disturbance is unknown. The weather has been more cold and rainy this year, keeping more visitors away. Park managers are in part attributing the success of 20 piping plover nests, a record year, to the lack of visitors.

Other areas of concern mentioned by managers, but not visited:

Old Inlet

The Old Inlet area receives high visitation due to an easy access trail from the ocean side. Jet-skis often ride close to shore in this area (illegal) and may come ashore at times.

Sexton Island

This Island is located on the western most boundry, bay side of Fire Island but is not considered National Seashore. A tern colony has established itself on this island and most recently, the federally listed Roseate Tern. There has not been much attention paid to this island from a visitor management perspective.

Hospital Island

Located on the eastern bay shore of Fire Island, Hospital Island has a campsite located on it, and managers are unsure how often canoers and kayakers stop there. This is an area we will visit and document in the future.

Other Concerns

Canoes and Kayaks have become more popular recently and managers do not know the amount of use the bay side of the island is receiving from this type of recreation.

Gateway National Recreation Area

Project Staff: Christopher Monz, Heather Bauman, and Erica Young.

Park Staff Present at Jamaica Bay Unit: Kim Tripp, Dave Avrin, and Dave Taft

Breezy Point

Park Staff Present: Sue Gilmore

Breezy Point is an area with high resource protection and high visitor use. There is a tern colony, one of the largest on the east coast, located here with mostly common terns, a few Roseate Terns, and Piping Plover. Piping Plover populations have been declining on this beach, even though visitors are only allowed to walk, fish, and sunbath. The Plover have been competing with tern and gull populations for space. Managers have controlled the gull population by collecting the eggs every year and destroying them. Research is also under way to figure out how to remove some of the grassland to make more open sand available for the plovers to establish nests. The grass has taken over due to a lack of storm activity since the early 90's.

On weekends the beach is packed with visitors and the plovers have difficulty getting to the shore to eat. Managers also have conflicts with several private clubs along the beach. The surf club, for instance has created a boardwalk down to the beach for disabled persons. If a plover nests near the boardwalk the park service must block the area off and with the help of the surf club, build a detoured route. This is time consuming and costly.

Fort Tilden/Riis Park

Park Staff Present: Sue Gilmore

Both of these units contain piping plover habitat as well as least terns. The black skimmers seem to be deserting these areas. There are large areas marked off for these birds that protect the sea beach amaranth as well. Around the enclosures the beach is mechanically cleaned on a regular basis, as this is an extremely popular area for beach activities.

Other areas of concern, not visited

Bergen Beach

Bergen Beach has shallow tidal creeks, marsh, and woodlands. Horseback riding is permitted here and managers are concerned about the extensive social trails being created as a result. There are about two miles of managed trails and a web of social trails coming from the main trails. There is concern over the trampling of native vegetation, manure runoff into the bay, and the impact the horses are having on dune stability.

Staten Island/Great Kills Park

Park Staff Present: Tom O'Connell

The majority of visitors come to Great Kills to go fishing along the beach or to participate in an organized sporting event. There are no federally listed species on the Great Kills unit. The salt marsh and beach receive a huge amount of trash that washes ashore. The beaches are regularly cleaned mechanically. Adjacent to the salt marsh is a sewage plant that releases into the ocean. Some visitors travel into the forest behind the marsh to bird watch, however no social trails were observed. A few social trails were observed leading out from the beach area into the forested area.

Due to the constraints of this project visitor impact assessment does not seem appropriate for this area. There are no significant natural resource protected areas, and it seems monitoring would not be of benefit to management operations.

Sandy Hook

Park Staff Present: Bruce Lane

The Sandy Hook Unit is accessible by one entrance only. When the parking lots are filled (approximately 5,000 parking spaces) the park closes the gates until an adequate amount of visitors leave to allow further entry. This occurs on approximately 10 weekends per year during the summer peak season (Memorial Day to Labor Day)

The Coast Guard occupies the northern tip of Sandy Hook in a facility within the park boundaries. There is some conflict with land use priorities. The Coast Guard uses dirt bikes and ORV's to patrol the northernmost section of the beach for the security of ships passing close to shore from the nearby Naval weapons station. The coast guard beach is the only beach they do not close off the inter-tidal zone for the plovers. .

There are four campsites on Sandy Hook reserved for small groups, 30 people per campsite. The campsites seem to generate little impact outside of the designated area.

Sandy Hook contains habitat for several endangered species including: Piping Plover, Sea Beach Amaranth, and possibly the Tiger Beetle (the park has tried to reintroduce the tiger beetle, results are still unknown).

Sandy Hook has a significant population of Sea beach Amaranth, especially on its southern shores where particularly numerous. The Amaranth is currently growing in the piping plover protected zones- a significant amount of area - since Sandy Hook keeps the historical plover nesting sites marked off as well as the current ones.

Sandy Hook Trail

Many social trails were observed departing from the northern end of the trail, including Fisherman's trail. Fisherman's Trail leads down to the beach, several social trails parallel this trail, apparently because visitors prefer to walk on hard ground instead of the sand. The beach has a large shorebird enclosure marked off, although visitors are observed inside the restricted area, fishing.

Horseshoe Cove

Fishermen heavily use the beach and bay side of horseshoe cove. South of horseshoe cove is a marsh, which is marked and fenced off to visitors, however visitors are still observed crossing the boundary to go crabbing and clamming. Between the marsh and beach side of horseshoe cove are many social trails throughout the area.

Spermaceti Cove

There is one main boardwalk leading over the marsh, with an ending deck. It does not appear that visitors go into the marsh or have access to the cove by another means. The cove also contains a holly forest that is closed to the public.

South Beach

Plover sites are marked off all the way to the inter-tidal zone so that the plover have easy access to their food source. Pets are not allowed on the beach while the plover and other nesting shorebirds are present from March 15 through Labor Day. Some visitors were observed on the other side of the restricted area.

Plum Island

This area contains tidal pools and mud flats. Visitors allow their dogs to run around here. School groups often come to observe wildlife. There are no signs posted informing visitors about appropriate behavior. Bruce Lane commented that this is due to management indecision about whether to pool the visitors in one area or to allow them to disperse. There are several social trails around marsh and traveling toward the ocean side. Visitors are observed picnicking, fishing, and setting up tents.

Gunnison Beach

Bird restricted areas not marked off to inter-tidal zone. This is due to loss of plover chicks due to flooding and fox.

Other Areas of Concern, Not Visited

Skeleton Hill Island

This island receives visitation from visitors on jet-skis, canoes, and kayaks. Many people fish on its western and southern shores. Illegal clamming occurs often. Managers are concerned about its condition because they do not get to check on it very often.

Appendix 2

Brief Summary of Second Phase Site Visits: Colonial NHS (COLO) and Assateague Island NS (ASIS)

Visit Dates: August 3-7, 2003; October 18-20, 2003

Project Staff: Yu-Fai Leung, Christine Ingle (NC State University)

Park Staff Present:

COLO -- Charles Raffkind (Natural Resource Specialist), Jimbo Thompson (law enforcement)

ASIS -- Carl Zimmerman (Chief, Div. of Resource Management), Cathy Galgano (GIS specialist)

Purpose

As Colonial NHP (COLO) and Assateague NS (ASIS) have been identified as two of the high-priority park units for this project, a follow-up visit to COLO and ASIS was conducted in August 2003 to:

- 1) Confirm with each park's Network contact about the most salient visitor impact concerns and examine emerging impact issues;
- 2) Identify and inspect high-priority sites within each park as potential sampling locations for Vital Sign indicators in Phase 3;
- 3) Meet with the park's GIS specialist to discuss spatial data availability and the data need; and
- 4) Pilot test a small number of indicator measures as time permitted.

Activities at COLO

The discussion with COLO park staff confirmed the major impact concerns as identified in Phase 1 research and gained new insights on emerging issues such as preference in fish species by various ethnic groups. The park staff indicated that Felgates, Indian Creek and Mill Creek areas are at the top of their priority list and suggested that we include these sites in the next phase of this project. These high-priority sites were inspected and photos taken for documentation purposes. We also evaluated the available GIS data for the park and were provided with a CD with selected GIS data themes. Limited pilot test of GPS mapping of visitor use areas was conducted.

Activities at ASIS

The discussion with ASIS park staff confirmed the major impact concerns identified in Phase 1 research. In addition, several emerging impact issues were also discussed, including kite-surfing and use of personal watercraft. The information need for ORV use distribution was emphasized by the park staff. With respect to trampling impacts to

vegetation and soils the park staff identified two campsites (Little Level and Tingles) as the high-priority areas for field testing in summer 2004. The GIS data availability was also evaluated at this meeting. As requested by the field staff the park's GIS specialist provided a CD with selected data themes.

A specific objective for this visit was to pilot test draft procedures developed for assessing wildlife-visitor interactions. The park staff provided a general overview of the latest development of the management issue of feral horses-visitor interactions. Based on the recommendations of the park staff we revised the draft procedures and pilot tested the revised procedures in the park. GPS mapping of interaction locations was also tested. One more site visit is planned in October 2003 to collect additional data, photos and videos in order to assess inter-rater reliability of the procedures.

Appendix 3

Citations of Reports, Presentations and Publications to Date

Reports

Monz, C., Y.-F. Leung, H. Bauman and C. Ingle. 2003. National Park Service Coastal Visitor Impact Monitoring: Phase 1 Project Report. Final report submitted to USDI National Park Service, Northeast Coastal and Barrier Network. (Completed March, 2003)

Monz, C., Y.-F. Leung, H. Bauman and C. Ingle. 2003. National Park Service Coastal Visitor Impact Monitoring: Phase 2 Preliminary Report. Report submitted to USDI National Park Service, Northeast Coastal and Barrier Network. (Completed July, 2003)

Presentations

Ingle, C., Y.-F. Leung, C. Monz and H. Bauman. Monitoring visitor impacts in coastal national parks: A review of techniques (Poster). George Wright Society Conference on Resource Management in Parks and on Public Lands; April 18, 2003; San Diego, CA.

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